CloudRoom: A Conceptual Model for Managing Data in Space and Time

Lucia Terrenghi
Vodafone GROUP R&D
Chiemgaustrasse 116,
D-81549 München,
lucia.terrenghi@vodafone.com

Kátia Serralheiro
Human-Computer Interaction Institute
Carnegie Mellon University
5000 Forbes Ave,
Pittsburgh, PA 15123
katia.serralheiro@gmail.com

Thomas Lang
Vodafone GROUP R&D
thomas.lang@vodafone.com

Martin Richartz
Vodafone GROUP R&D
martin.richartz@vodafone.com

CHI 2010, April 10–15, 2010, Atlanta, Georgia, USA.
ACM 978-1-60558-930-5/10/04.

Abstract
Cheap broadband access and hosting infrastructure on the web have enabled many services that traditionally would have been deployed as local desktop applications to be hosted and accessed via the Internet - in the Cloud - from any network-connected device. This trend is referred to as Cloud Computing. The movement towards a network-based environment implies novel conceptual models for storing, searching and sharing digital information on the web and across devices. In this paper we describe our concept design for management and visualization of resources in the Cloud Computing paradigm. Based on our insights from qualitative user studies, we design an environment which reflects the way people use spatial and temporal memory to organize and navigate through artifacts. We then discuss how our concept builds upon existing work and its implications for future work.

Keywords
Cloud computing, user interface, design, visualization

ACM Classification Keywords
H5.m. Information interfaces and presentation

General Terms
Design

BACKGROUND AND MOTIVATION

Applications and services are increasingly distributed into the web, rather than locally stored and installed on a single device. Thus, information and data manipulated with web applications normally 'live' in the Internet, also called "Cloud". Here, information is created, shared, updated in real time. This trend is referred to as Cloud Computing, and implies a fundamental paradigm shift[1].

Whereas most of the times people still store their data in multiple copies across different devices (e.g., home PC, office PC, laptop, mobile device, memory stick, and CDrom), more and more people are using the Cloud as remote back-up, allowing a third party (e.g., Google Docs, Zoho) to store their data and control access to it. Thus, Cloud Computing brings some major changes in the way people organize, manipulate, store, share, and archive digital resources. These data or applications become entities which live on the web, and the end user is accessing and manipulating instances thereof via a thin-client (e.g., a browser) residing on her device. To access that information, people must not use a specific device any longer, but rather have connectivity to access the Internet, opening on-demand a sort of 'window' to the Cloud on any device at hand.

As resources are no longer physically stored on a specific device, it becomes clear that Cloud Computing influences the user mental model and experience with digital artifacts, especially in terms of organization and retrieval of information. This implies novel user interfaces to convey a conceptual model that allows people to navigate and orient themselves in the Cloud, and to define their landmarks for finding and using their information at any time and from any device.

[1] For a description of the overall concept of Cloud Computing see also http://en.wikipedia.org/wiki/Cloud_computing

We see that these issues are highly relevant for HCI, in terms of information architecture, user interface design, information visualization, and user research. Still, the implications of Cloud Computing on the user experience have been limitedly addressed by the CHI community so far.

In this article we report on some of the work we have been undertaking in this space: While by no means being conclusive, our contribution aims at raising a constructive discussion around this topic, possibly inspiring further approaches. Although we believe that the implications of Cloud Computing on users' interactions are far more complex, encompassing privacy, security, and reliability issues, in this article we focus on the user experience and mental model of information storage and retrieval.

CLOUD COMPUTING AND USER EXPERIENCE

In order to tackle the problem of data storage and retrieval in the Cloud, we went through different iterations of qualitative user studies, encompassing two rounds of in depth interviews with up to 15 users from different segments; an online survey on the use of web applications with 20 users; as well as an expert workshop. Through out these activities our main goals were to:

- Understand current practice of storage and sharing of data: In this context, understand what parameters people use to organize different types

Figure 1. On the mobile phone, users can pre-select the information they wish to upload or update in the CloudRoom.

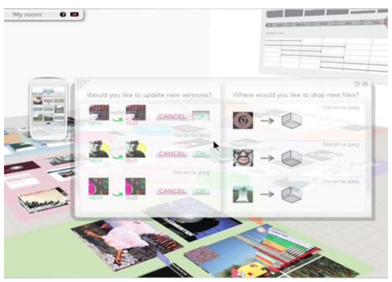

Figure 2. When the user connects to the CloudRoom, from her handset onto a larger display, a proxy of the handset appears: The user can manipulate the proxy and place her new data in the space, or decide whether to update existing information.

of information (e.g, photos, documents, contacts) and their acquaintance with tagging;

- Understand how data is accessed and used across an ecology of devices such as business and home PCs, laptops and mobile phones; in this context, we wanted to understand users' mental model of data storage vs. synchronization;

- Investigate motivation and barriers of using web applications.

For lack of space, in this article we won't articulate our iterative approach into detail, but we'll focus on the main findings that informed our design and can inform others'. Mostly, people structure their data according to the data type (e.g., photos, music, videos, documents, presentations) and into thematic folders. Such folders are normally labelled with the name of activities or personal); the name of an event; or the name of people who are somewhat related to the contained information or the owners of that information (especially in home PCs which are shared by multiple people). Within a folder, data is normally sorted by name, or by date of editing. This happens especially when people want to retrieve the most updated version of a file, thus using time for orientation through their data sets. Some people also have "temp" or "temporary" labelled folders, where they store information which is either often edited or versioned, or when they download or cluster data that need to be organized later on.

Organization into folders is most common, although some more tech-savvy users tag their data for facilitating retrieval in a later stage. E.g.: "Within Mac OS some files are tagged to alleviate spotlight search and smart folder. These folders are at least a query, but displayed as a folder". Especially when looking for information that hasn't been accessed for a long time, some people rely on tools such as Desktop search.

People tend to save multiple copies of their information on different devices to make sure that it is safe somewhere and/or that it can be accessed in different contexts (e.g., while at home, using a Desktop PC, and on the way, using a notebook or a smart phone). In order to use and share personal data on different devices, several people use USB memory sticks and CDroms, which serve as physical tokens to transport data. There seems to be a sort of trade-off between safety (long-term access, for storage) and accessibility (short-term access, for editing and sharing). Saving data on the web (e.g., e-mails, photos) is perceived as an additional back-up to access information from everywhere and make it accessible to others.

People have limited understanding of the difference between storage and synchronization. Versioning and organization is perceived as a burden and some forms of automated organization would be desirable. Some users stated, for example: "I save everything on the desktop until it's too full, than I save everything in one folder. I don't have a system. I would appreciate an automatic way of structuring". Integrated services with automatic synchronization and update could diminish versioning and organization effort. Another participant: "Actually I would like to have everything [*all data*] in sync, but without effort."

As users are acquainted with interacting with an ecology of devices, they would like to be able to access the same resources across different peripherals and

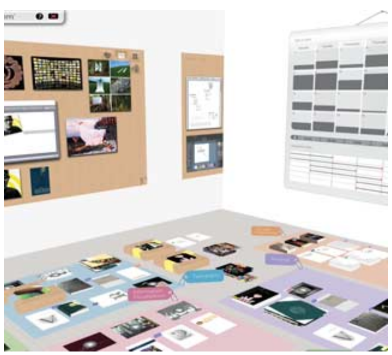

Figure 3. The CloudRoom consists of three planes with distinct functionalities. The left-hand wall holds work-in-progress, the floor is long-term, persistent storage, and the right-hand wall displays the timeline overview.

perform different tasks according to the different situations. In particular, people seem to prefer using the most portable device as much as possible, until the input/output bandwidth is sufficient for accomplishing the desired task. E.g.: "I use the iPhone for everything until I have to type long texts"; another user, talking about web applications: "From every different device you get the view you need. It's all about the views. For example Word. On the mobile I just need the possibility to read a file. To edit it, I switch to the PC."

Accessibility, shareability and collaboration are some of the main motivations for using web applications and tagging. On the other hand, privacy concern and reliability of the service - due to connectivity and offline interaction - constitute the main barriers. An interviewee, expressing this trade-off: "I don't like the thought of having all your stuff saved online. Is it secure? But you have to suppress that. The problem relies on the Internet itself. The availability from everywhere prevails."

CHALLENGES AND DESIGN RATIONALE

Building on such insights, we designed a concept which tackles the following challenges:

- There is a trade-off between ownership and delegation of control: People want to be able to create their own structures and landmarks that allow them to navigate through information, but at the same time they need to be supported by automation to efficiently manage complex and broad data sets.
- An ecology of devices is enabling people' access to data and applications that are remotely stored: People expect to have consistent access to information from multiple peripherals, but desire an interface (a "view") which is suitable to the situation and device at hand. This implies that the relationship between devices and data needs to be somewhat represented.

Taking those challenges into account, and elaborating on the insights of our user studies, we made the following assumptions:

- The time dimension emerged as a key criterion for people to structure their data, as well as their interactions across data spaces (e.g., using "temp" folders, sorting data by date, and adopting storage devices as tokens). Being time a convention, it can leverage automation of data organization as well as retrieval, and can overlay the raw data with a metadata layer. This, implicitly, opens further possibilities for versioning and sharing information.
- As mobile broadband is increasingly available and affordable, a smart phone can become the preferred ubiquitous access point to private and shared data, which are stored in the web. Besides, the capturing capabilities of mobile devices (e.g., video and audio) afford the generation of new data on the go. Still, its display size affords the visualization of a limited amount of information. We speculate that similarly to the way in which USB memory sticks are often used for transporting data across devices, smart phones can transport selected 'cloud views' across devices. People will have a complete view of their data space when

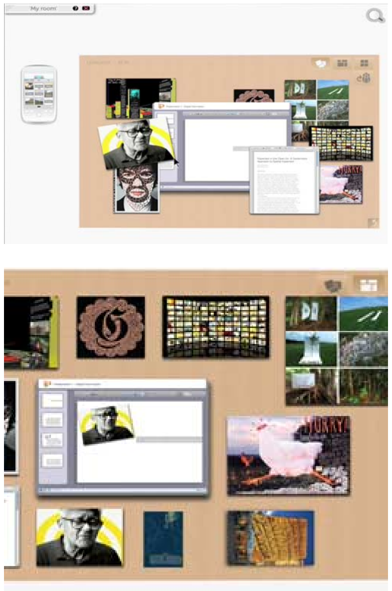

Figure 4. The work in progress dimension (short-term access for manipulation) reflects the purpose of capturing instances of the work, thus supporting visual and contextual memory. Considering that people often work on several projects simultaneously, multiple sessions can be open at the same time. Users can keep sessions open as long as they wish and can share a working session with their peers and work within it until it is complete: then the session is closed, named and save it in the storage floor.

interacting with larger displays, whereas they will interact with sub-sets thereof on the mobile device (see Fig. 1).

Building on these assumptions, we designed the CloudRoom, a concept for a user interface to the Cloud. For a comprehensive description of the concept we refer to the video attached to this article, and to the figures. Below, we summarize its main features.

THE CLOUDROOM

The CloudRoom is our design for an online environment where users can structure, manipulate, retrieve and share their information in the Cloud. Our concept is based on three dimensions, which are represented by the walls and the floor of a virtual room (see Fig. 3): first, the long-term storage for the organization of data in a certain location (on the floor, see Fig.5); second, the short-term manipulation of data in temporary sessions (on the left-hand wall, see Fig. 4); and third, the overview through time (on the right-hand wall see Fig. 6). This approach reflects our attempt of supporting different stages of the users' workflow and her orientation through time and space. As discussed by Kirsh [2] people use space to display tools and orient themselves in the task, with epistemic actions that support cognitive offload. Whereas tools might be stored in some specific locations most of the time (i.e., long-term storage), they are spatially arranged in temporary sessions (i.e., short-term manipulation) when people aim at accomplishing a specific goal at hand or working on a project (e.g., cooking a recipe, as in Kirsh' example). Additionally, given the idiosyncratic dynamism of digital information, we bring the time dimension in the space, to support users with an overview of the evolution of their interactions throughout time.

As anticipated, we consider the mobile device as the starting point of interaction: With their handset, users can capture or edit data on the way, which they can then either update or organize in the CloudRoom. Here, by manipulating a graphical representation of the handset in the 3D environment (see Fig. 2), users can handle the mobile device as a token of information. By dragging the mobile on the temporary sessions wall, the data that was pre-selected on the mobile screen can be displayed on the wall, thus opening a temporary session. Here resources can be arranged in different ways, to support different working styles and visual memory.

Users can work on multiple sessions in parallel. Within a session, 'external' resources from the Cloud as well as 'internal' ones from the persistent storage (the floor) can be included for manipulation. To do so, users can search their CloudRoom by data type and tags, or browse the timeline. When objects are taken from the floor to the temporary session, users manipulate a copy of the original resource. A session can also be shared with the user's contacts, thus enhancing shareability and collaboration in real time.

To permanently edit a resource, users must access and directly manipulate an item on the floor. In this way we break the conventional distinction between application and data: In our view, web applications and data simply become objects in the network. Objects might have different types (e.g., image, text, video) but they are basically application-agnostic. People can directly manipulate them across different services, hence

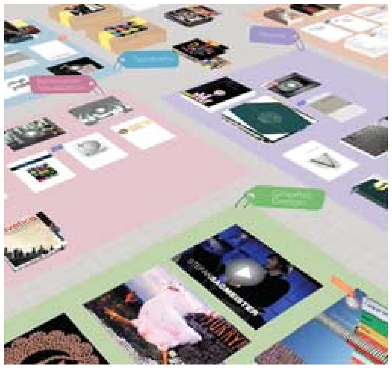

Figure 5. The long-term storage plane (the floor) works similarly to a desktop, and support users' spatial organization. Related documents can be piled or grouped together in a certain area. Objects and groups can be tagged to make search easier. The plane can be zoomed and panned to navigate through the data set.

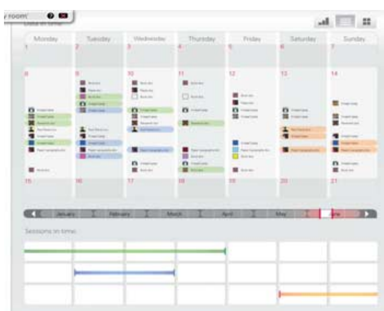

Figure 6. In the timeline overview, users specify the time interval they wish to view. The combined visualization of data and sessions allows users to see which resources from the list were being used in a session.

radically changing the application-based fashion of interacting with digital information.

Finally, the timeline (see Fig. 6) displayed on the right-hand wall provides an overview of the evolution of all data in the room, both in the storage floor and in the sessions. This feature is meant to enhance versioning - as it enables visualizing a previous state of an object - and facilitates searching, since users can set a specific period of time and visualize the data and parallel sessions (or projects) they have been working on.

RELATED WORK AND DISCUSSION

To date, most web applications offering data management present a list visualization with hierarchical structure. The folders and file structure forces the user to categorize and name every document created. The hierarchical nesting of folders hides substantial information, forcing users to recall where a specific document lies. Users don't have an immediate way to determine the number, type or size of the data within folders.

To facilitate spatial orientation, in our concept objects can be disarrayed on a plane - the floor -similarly to the Desktop metaphor: differently though, the plane is zoomable and pam-able, like in zoomable user interfaces such as Pivot[2]. Objects can be placed in different areas according to personal criteria, can be tagged, and can be piled. The information appears on an infinite zoomable and pam-able view of the overall documents, instead of being hidden and nested in folders, thus maintaining transparency of content and affording an overview of the data set. The idea of piles and physical behavior of digital objects relates to the Bumptop interface [1], which affords spatial orientation in a 3D virtual environment. Differently from Bumptop, we attribute a distinct function to the different planes of the 3D environment, and we bring the time dimension in the space, to provide an additional reference frame to contextualize search in the dataset. Another model we were inspired from, especially for the timeline visualization, is Liquifile [3]. This visual browser, which provides and overview of the information density and data size, considers the time factor and allows browsing within a reduced scale by magnifying the items on hover. Additionally, it supports `flat browsing', in case users whish to remove the hierarchical folder structure.

In conclusion, our approach takes into deep consideration user behaviors and technology trends. It builds on the consideration that organization will be further enhanced by the fact that a number of metadata is automatically available, such as time and date of creation/modification, and data type. The concept obviously still needs to be validated in a functioning prototype, but we believe it is significant step in the exploration of user interfaces for Cloud Computing.

[2] Pivot is a visualization technique for data management developed by Microsoft Live Lab, see http://www.getpivot.com/

References

[1] Agarawala, A., Balakrishnan, R. Keepin' it Real: Pushing the Desktop Metaphor with Physics, Piles and the Pen. *Proc. CHI 2006,* 1-9.

[2] Kirsh, D. 1995. The intelligent use of space. *Artif. Intell.* 73, 1-2 (Feb. 1995), 31-68.

[3] Liquifile 1.0. http://www.liquifile.info/